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Antiferromagnetic properties of a water-vapor-inserted YBa 2Cu3O6.5 compound studied by NMR, NQR, and μSR

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Abstract

We present a detailed NQR, nuclear magnetic resonance (NMR), and μSR study of the magnetic phase obtained during a topotactic chemical reaction of YBa2Cu3O6.5 high-temperature superconductor with low-pressure water vapor. 65Cu-enriched samples have been used for NQR/NMR studies which allows to get a good resolution in the Cu(1) NQR and Cu(2) zero field NMR (ZFNMR) spectra. It is shown that the NQR spectrum of the starting material transforms progressively under insertion of water, and almost completely disappears when about one H2O molecule is inserted per unit cell. Similarly, a 65Cu ZFNMR signal characteristic of this water inserted material appears and grows with increasing water content, which indicates that the products of the reaction are nonsuperconducting antiferromagnetic phases in which the copper electronic magnetic moments in the CuO2 bilayers are ordered. The use of 65Cu-enriched samples allowed us to reliably resolve three different copper resonances which correspond to different internal magnetic fields. The antiferromagnetic phases are also felt by proton NMR which reveals two sites with static internal fields of 150 and about 15 Gauss, respectively. μSR studies performed on a series of samples prepared in the same way as the 65Cu-enriched ones reveal two muon sites with the same local fields as the proton sites, which vanish at T ≈ 400 K. This indicates that muons preferentially occupy proton vacancy sites, and that the magnetic phases have similar Néel temperatures as the other bilayer undoped cuprate compounds. An analysis of the internal fields on the different spin probes suggests that they can be all assigned to a single magnetic phase at large water content in which the Cu(1) electron spins order with those of the Cu(2). The detailed evolution of the spectra with the progressive increase of water content is shown to be compatible with a coexistence of phases during the early stages ot the reaction. It appears that even samples packed in paraffin underwent a transformation of a substantial part of the sample after 6 years storage in atmosphere. Samples packed in Stycast epoxy resin heated moderately to a temperature (200°C) undergo a reaction with epoxy decomposition products which yield the formation of the same final compound. It is clear that such effects should be considered quite seriously and avoided in experiments attempting to resolve tiny effects in these materials, such as those performed in some recent neutron scattering experiments.

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